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OBSERVATIONS ON THE FEEDING HABITS OF SOME SOIL COLLEMBOLA FROM AN ABANDONED FIELD IN KERALA

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Study of the gut contents of three species of soil Collembola viz., *Alloscopus tetracantha* BORNER, *Microparonella duodecemoculata* PRABHOO and *Cyphoderopsis decemoculata* PRABHOO collected from an abandoned field revealed both qualitative and quantiative differences with overlap in the type of materials consumed by these species indicating that these insects were capable of food selection. *A. tetracantha* mostly fed on amorphous substance and higher plant material, *C. decemoculata* on amorphous substance and spores of the fungi *Curvularia* and *Cordana* plus an unidentified fungal spore and *M. duodecemoculata* on amorphous substance and spores of the fungus *Epicoccum* and of another unidentified fungal species. A large number of individuals under each species were with empty gut as they were in the nonfeeding phases of the intermoult period. Tentatively it may be said that 33–54% of *A. tetracantha*, 50–89% of *M. duodecemoculata* and 33–77% of *C. decemoculata* at any time of the year would be in the nonfeeding phase in the field.

(*Key words :* **Collembola, food, moulting, fungi)**

INTRODUCTION

Several studies on Collembola have shown that these insects are found in a variety of terrestrial habitats and that in certain types of soil they are also found in very large numbers often reaching a density of several thousands per square meter. Under the humid tropical conditions of Kerala they have been found to exist not only in large numbers but they also showed considerable species diversity in the same habitat (PRABHOO, 1976). One of the questions that would naturally arise on taxonomic and ecological studies of Collembola in any habitat would be as to whether several species coexisting in a habitat could have identical food sources.

Few early investigators like AGRELL (1940) thought that Collembola were unspecialised feeders because individuals of the same species in two localities showed very different items of food in their gut. BELLINGER (1954) thought that due to the small size of their mouth parts the Collembola might feed mostly on the microflora. PACLT (1956) considered unicellular algae, moss and fungal hyphae to be the more common food items of these insects. POOLE (1959) stated that although the most important item of food of Collembola to be fungus, decaying plant remains and detritus, the larger species fed on fungal material, predominantly hyphae and smaller species on humus. CHRISTIANSEN (1964) provided an excellent review of the studies on the food of Collembola.

The present study was undertaken in order to bring to light the food of three species of Collembola living together in a habitat to see whether, under field conditions, they showed any food preference and whether their food sources were identical.

METHODS EMPLOYED

Surface soil along with litter was collected from an abandoned field in the University campus. Soil samples were extracted using a series of Berlese-

Tullgren funnels and the Collembola were collected in 70% ethyl alcohol. For studying the gut contents, simple methods were described by KNIGHT & ANGEL (1967) and DE WITH & JOOSSE (1971). For the quantitative estimation of the particles ANDERSON & HEALEY (1972) described an elaborate technique in which the gut contents in water were repeatedly frozen and thawed and the dispersed particles stained lightly. MASSOUD & NAJIT (1976) recently dealt with in general the techniques employed in studying the feeding habits of Collembola. In the present study individuals of the three species of Collembola viz., *Alloscopus tetracantha* BORNER, *Microparonella duodecemoculata* PRABHOO and *Cyphoderopsis decemoculata* PRABHOO fixed in 70% ethyl alcohol were mounted directly in polyvinyl alcohol (SALMON, 1954). The insects became highly transparent in this medium within a week's time. The food band and the particles in it were also rendered sufficiently clear making it possible for their categorization. The categorization of the particles was made as recommended by KNIGHT & NAGEL (1967). Relative abundance of the various materials in the food band was assessed on an area basis by drawing the food bands on a graph paper using camera lucida. Stage in the moult cycle was determined based on the nature of the cuticle (DE WITH & JOOSSE, 1971 ; THIBAUD, 1976).

OBSERVATIONS AND DISCUSSION

All the species studied possessed mandibles provided with incisors and well developed molar areas. The individuals of the three species were collected from the field on several occasions from October to December 1976 and from June to July 1977, no animals being obtained in the interverning period.

The materials in the gut could be classified into four broad categories viz., higher plant particles, fungal materials, amorphous substance and mineral particles (Table 1). The fungal materials were hyphae and spores. The relative proportion of the various substances in the gut contents varied in the three species. KNIGHT & ANGEL (1967) thought that the amorphous substance in the gut of *Tomocerus* species they studied, was a mixture of dietary components which had undergone partial digestion. If this was true then *A. teracantha* and *C. decemoculate* fed mostly on amorphous substance which formed 69% of their gut contents. The techniques of ANDERSON & HEALEY (1972) would exclude this amorphous substance and hence would be inadequate for the study of the gut contents of the species treated here. In addition to the amorphous substance *A. tetracantha* fed on higher plant material which formed about 24% of the gut contents and also a little of the fungal material, almost completely composed of fungal hyphae (Fig. 1 A). *C. decemoculata* on the other hand preferred fungal spores to higher plant material, the former amounting to 30% of the gut contents (Fig. 1 B). Higher plant material was found to be very low forming 1% of the gut contents. The remarkable difference noted in the feeding habits of *M. duodecemoculata* was

TABLE 1. Mean percentage of various food items in the gut contents of Collembola collected from an abandoned field.

Name of species	% higher plant material	% fungal material	% amorphous substance	% mineral particles	Size of commonly found food particles in/μm
A. tetracantha	24	6	69	1	18.2×13
C. decemoculata	1	30	69	traces	15×3.6
M. duodecemoculata	3	66	31	traces	18.2×10.4

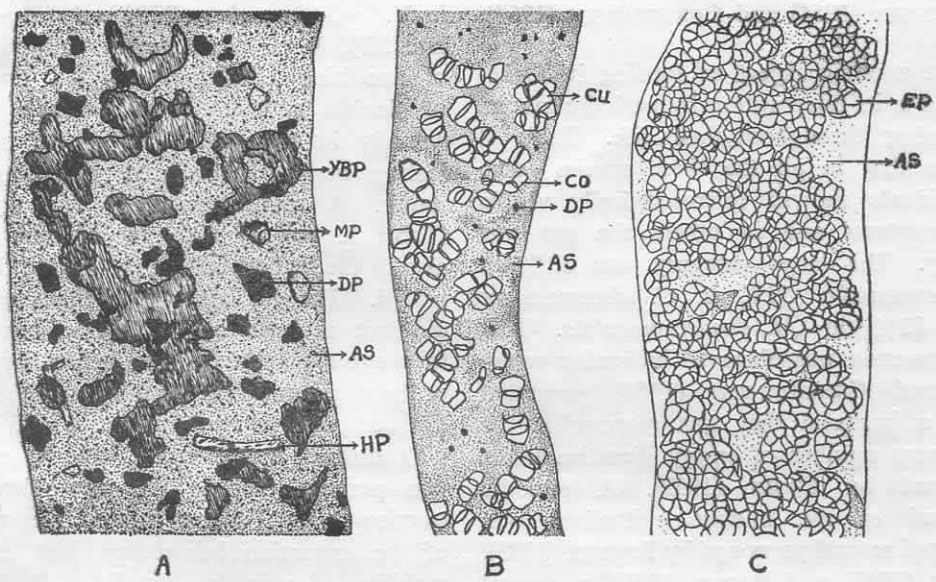


Fig. 1. Relative abundance of food materials in the gut contents. A *Alloscopus tetracantha* BORNER. B. *Cyphoderopsis decemoculata* PRABHOO, C. *Microparonella duodecemoculata* PRABHOO. AS—Amorphous substance ; Co—Spore of *Cordana ;* Cu-Spore of *Curvularia ;* Dp—Dark particles of higher plant origin; Ep—Spore of *Epicoccum ;* Hp—Hyphal fragment; YBP—Yellowish brown particle of higher plant origin, MP—Mineral particle.

that this species fed mostly on fungal spores (Fig. 1 C) which formed 66%, the amorphous substance forming 31% and materials of higher plant origin only 3% of the gut contents. None of the species consumed mineral matter to any appreciable quantity. In *A. tetracantha* mineral matter formed only 1% and in others only traces of this were found in the gut contents. Although both *M.duodecemoculata* and *C.decemoculata* fed on fungal spores, in the former species the spores of *Epicoccum* and of an unidentified species were found (Figs. 2 and 3), while in *C. decemoculata* the spores of *Curvularia* and *Cordana* and another unidentified species of fungus were found (Figs. 4 and 5).

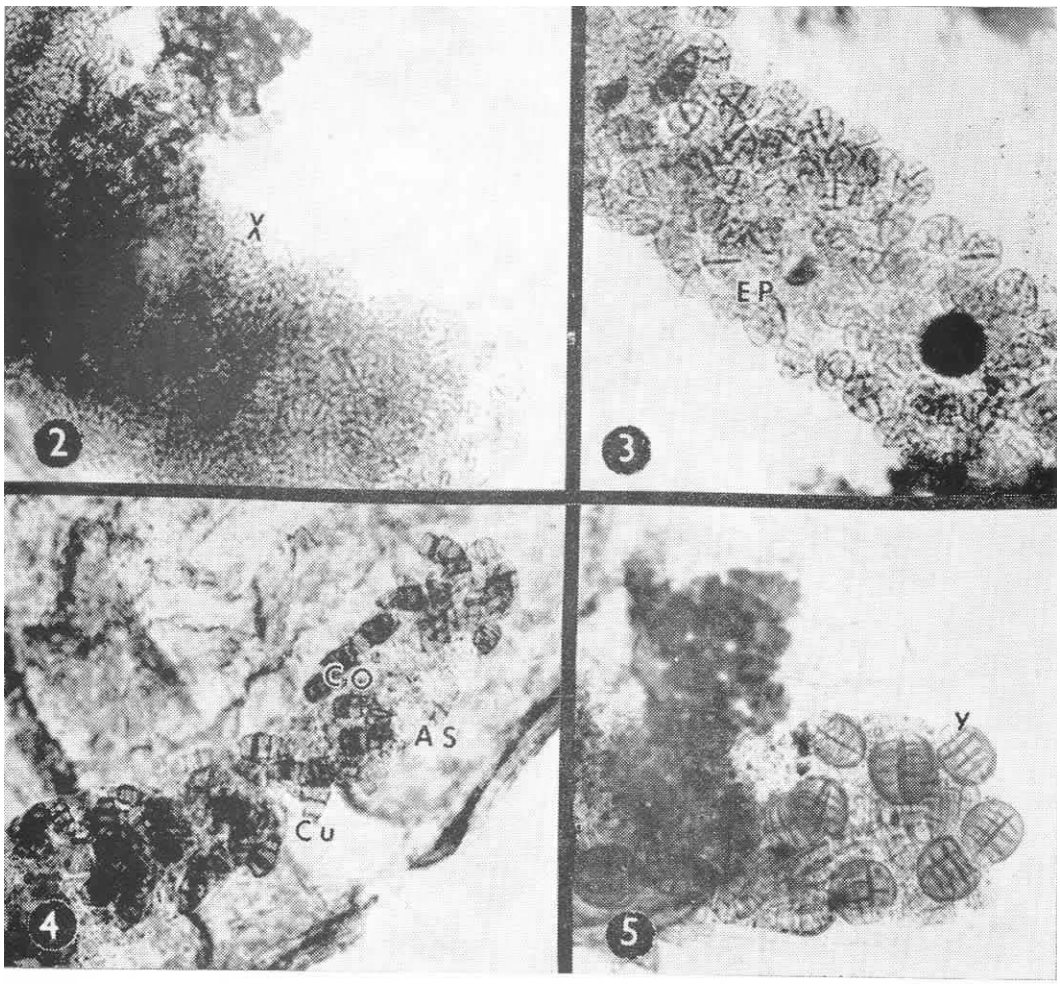
It appeared from this study that in spite of the considerable overlap in the food materials of the species living in the same place it was unlikely that the food sources of the two species would be completely identical. Display of this food differences by related species sharing habitats appeared to be in agreement with the general ecological concepts (DE BACH, 1966) and findings on oribatid mites in Kerala (HAQ & PRABHOO, 1976). The evidence presented here showed that the generalization that detritivore Collembola are unspecialised feeders (HALE, 1967) is untenable when it is reasonably presumed that the small percentage of higher plant material found in the gut of *Microparonella* and *Cyphoderopsis* and the fungal material in the gut of *Alloscopus* was due to accidental intake rather than due to deliberate feeding. Apparently while some Collembola could feed on higher plant material others are likely to thrive more on fungal material

than on other substances as predicted by BELLINGER (1954) and CHRISTIANSEN (1964).

Yet another aspect of feeding in Collembola is its interruption by periodic moults occurring throughout their life. Table 2 shows that in all the three species some individuals showed microscopically visible gut contents and in others the gut was empty. The latter category was 39% in *A. tetracantha* 59% in *C. decemoculata* and 82% in *M. duodecemoculata*. This phenomenon was observed by earlier workers and CHRISTIANSEN (1964) suggested that a bacterial diet was responsible for the large number of empty digestive tracts reported by POOLE (1959). A periodic renewal of the midgut epithelium was reported several years ago by SOMMER (1885), DENIS (1949) and PACLT (1956) in several Collembola. This feature is characteristic of all Collembola and THIBAUD (1968,1976) clearly showed that in Hypoastrurids the empty gut was associated with both the early (Fasting period I) and late (Fasting period II) intermoult during each moult cycle. DE WITH & JOOSSE (1971) obtained similar results with five species of Entomobryidae. In the present study, among the animals with empty gut (Table 2, col. 6) 6% in *M.duodecemoculata*, 23% in *A. tetracantha* and 35% in *C. decemoculata* showed signs of moulting confirmed by the presence of double cuticle. These animals were actually in the latter half of the second fasting period immediately preceding the moult. A small percentage of animals (Table 2, col. 4) with gut contents were also in the second half of the second fasting period. The gut contents in these animals did not indicate active feeding but only failure to expell the contents before the onset of the degeneration of the midgut epithelium. The comparatively low number of individuals with distinct moult sign (Table 2, col. 8) was perhaps due to the incomplete extraction in the Tullgren funnels, the success of the extraction being dependent on the mobility of animals. DE WITH & JOOSSE (1971) already showed that the mobility of animals decreased during ecdysis and increased considerably after moulting. THIBAUD (1968) found that under laboratory conditions 60% of the Hypogastrurids at a time were found to be in the nonfeeding phase and in *Tomocerus* under field conditions nearly 66% had no gut contents (KNIGHT & ANGEL, 1967). The Col-

TABLE 2. Feeding and moulting stages in the individuals of Collembola collected from an abandoned field.

Name of species	Number examined	Number of individuals with					
		gut full	gut full & moult sign	empty gut	empty gut & moult sign	empty gut, no moult sign	moulting sign
A. teracantha	110	67 61%	7 10%	43 39%	10 23%	33 77%	17 15%
C. decemoculata	44	18 41%	3 16%	26 59%	9 35%	17 65%	12 27%
M. duodecemoculata	44	8 18%	1 13%	36 82%	2 6%	34 94%	3 7%



Figs. 2 & 3. Photomicrographs showing the gut contents of *Microparonella duodecemoculata* PRABHOO. X–Unidentified spore; EP–Spore of *Epicoccum*. Figs. 4 & 5. Photomicrographs showing the gut contents of *Cyphoderopsis decemoculata* PRABHOO. AS—Amorphous substance: CO—Spores of *Cordana* ; Cu—Spores of *Curvularia* ; Y—Unidentified spores.

lembola on an average were thought to feed only during 50% of their adult life (ANDERSON & HEALEY, 1972). In the present study it was found that at any time of the year 33%—54% of the individuals in *A. tetracantha*, 50%—89% of the individuals of *M. duodecemoculata* and 33%—70% of *C. decemoculata* under field conditions were in the nonfeeeding stage. Maintenance of normal growth and activity in these animals in spite of their relatively low feeding rate would be possible only if they showed a high degree of assimilation of nutrients from food as observed by HEALEY (1967) in *Onychiurus procampatus*.

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REFERENCES

AGRELL, I. (1940) A study of the Collembolan population in the Tornetask region of northern Lapland including overwintering conditions and migrations in the field at different periods. *Entdr. Med.*, **22** : 12–13.

ANDERSON, J.M. & I.N. HEALEY (1972) Seasonal and interspecific variations in major components of the gut contents of some woodland Collembola. *J. Anim. Ecol.*, **41** : 359–368.

BELLINGER, P.F. (1954) Studies on soil fauna with special reference to Collembola. *Conn. Agr. Exp. Sta. Bull.*, **491** : 1–67.

CHRISTIANSEN, K. (1964) Bionomics of Collembola. A. *Rev. Ent.*, **9** : 147–178.

DE BACH, P. (1966) The competitive displacement and coexistence principles. A. *Rev. Ent.*, **11** : 183–212.

DENIS, J.R. (1949) Le Insectes Apterygotes, 113–159 *in : Traite de Zoologie* **9**,: (ed. GRASSE, P.P.), Masson et Cie, Paris.

DE WITH, N.D. & E.N. G. JOOSSE (1971) The ecologica effects of moulting in Collembola. *Rev. Ecol. Biol. Sol*, **8** : 111–117.

HALE, W.G. (1967) Collembola, 397–441 **in** *: Soil Biology*, (ed. BUGRESS, A. & F. RAW) Academic Press, New York & London.

HAQ, M.A. & N.R. PRABHOO (1976) Observations on the feeding habits of oribatid mites from the soils of Kerala (Acarina : Cryptostigmata)-Panphytophages. *Entomon*, **1** : 133–137.

HEALEY, I.N. (1967) The energy flow through a population of soil Collembola, 695–708 *in : Secondary Productivity of Terrestrial Ecosystems*, (ed. PETRUSEWICZ, K). Polish Academy of sciences, Warsaw.

KNIGHT, C.B. & R.A. ANGEL (1967) A preliminary study of the dietary requirements of *Tomocerus* (Collembola). *Amer. Midl. Nat.*, **70** : 187–193.

MASSOUD, Z. & J. NAJIT (1976) Importance des techniques pour l' etude du regime alimentaire des Collemboles. *Rev. Ecol. Biol. Sol*, **13** : 147–153.

PACLT, J. (1956) *Biologie der primar flugellosen Insektan*, Gustav Fisher, Jena, 258 pp.

POOLE, T.B. (1959) Studies on the food of Collembola in a Douglas fir plantation, *Proc. zool. Soc. Lond.*, **162** : 71–82.

PRABHOO, N.R. (1976) Soil microarthropods of a virgin forest and adjoining tea fields in the Western Ghats in Kerala a brief ecological study. *Oriental Ins.*, **10** : 435–441.

SALMON, J.T. (1954) A new polyvinyl alcohol mounting medium. *Microscope*, **10** : 66–67.

SOMMER, A. (1885) Über *Macrotoma plumbea*: Beiträge zur Anatomie der Poduriden. *Z. wiss. Zool.*, **41** : 683–718.

THIBAUD, J.M. (1968) Cycle du tube digestif lors l' intermue chez les Hypogastruridae (Collemboles) epiges et cavernicoles. *Rev. Ecol. Biol. Sol*, **5** : 647–655.

THIBAUD, J. M. (1976) Relations chronologiques entre les cycles du tube digestif et de l'appareil genital lors de l' intermue des Insectes Collemboles, *Rev. Ecol., Biol. Sol*, **13** : 191–204.